

WHAT IS CLAIMED IS:

1                   1.     An acoustic monitoring method in laser-induced optical  
2     breakdown (LIOB), the method comprising the steps of:  
3                   causing at least one acoustic wave associated with a microbubble to  
4     propagate in a volume of material;  
5                   detecting the at least one acoustic wave to obtain at least one signal;  
6     and  
7                   processing the at least one signal to obtain information which  
8     characterizes the material, the microbubble in the material or a microenvironment  
9     of the microbubble.

1                   2.     The method as claimed in claim 1, the information  
2     characterizes the mechanical microenvironment of the microbubble.

1                   3.     The method as claimed in claim 2, wherein the information  
2     characterizes the viscoelasticity of the microenvironment.

1                   4.     The method as claimed in claim 1, wherein the information  
2     characterizes microbubble size.

1                   5.     The method as claimed in claim 1, wherein the at least one  
2     acoustic wave includes at least one acoustic wave reflected from the microbubble.

1                   6.     The method as claimed in claim 5, wherein the at least one  
2     reflected acoustic wave includes an ultrasound wave.

1                   7.     The method as claimed in claim 1, wherein the at least one  
2     acoustic wave includes an acoustic shock wave which propagates outwardly from  
3     an LIBO site and defines an acoustic point source.

1                   8.     The method as claimed in claim 7, wherein the microbubble  
2 is LIOB-induced and wherein the acoustic shock wave defines position of the LIOB-  
3 induced microbubble which acts as an acoustic reflector.

1                   9.     The method as claimed in claim 7, wherein the point source  
2 is determined by location of an additive in the material and wherein the additive  
3 enhances an electric field in the vicinity of the additive.

1                   10.    The method as claimed in claim 9, wherein the information  
2 characterizes a photodisruption threshold of the material with the additive which is  
3 substantially lower than a photodisruption threshold of the material without the  
4 additive.

1                   11.    The method as claimed in claim 10, wherein the information  
2 quantifies concentration of the additive.

1                   12.    The method as claimed in claim 11, wherein a single molecule  
2 of the additive is detected.

1                   13.    The method as claimed in claim 9, wherein the material  
2 includes at least one nanodevice having the additive and a linked therapeutic agent  
3 and wherein at least one laser pulse causes the at least one nanodevice to release the  
4 linked therapeutic agent into the microenvironment.

1                   14.    The method as claimed in claim 13, wherein the information  
2 characterizes therapeutic efficacy of the therapeutic agent in the microenvironment.

1                   15.    The method as claimed in claim 7, wherein the material has  
2 an additive incorporated therein and wherein the point source is a desired point  
3 source substantially smaller than a point source defined by a microbubble created  
4 within the material without the additive.

1                   16.    The method as claimed in claim 15, wherein the additive  
2 includes metal nano particles or domains.

1                   17.    The method as claimed in claim 1, wherein the microbubble  
2 is produced by at least one laser pulse.

1                   18.    The method as claimed in claim 17, wherein the at least one  
2 laser pulse includes a focused laser pulse.

1                   19.    The method as claimed in claim 1, wherein the microbubble  
2 is produced by at least one ultrafast laser pulse.

1                   20.    The method as claimed in claim 19, wherein the information  
2 characterizes a photodisruption threshold of the material.

1                   21.    The method as claimed in claim 1, wherein the information  
2 characterizes location of the microbubble within the material.

1                   22.    The method as claimed in claim 1, wherein the information  
2 characterizes microbubble behavior in the material.

1                   23.    The method as claimed in claim 4, wherein microbubble size  
2 is determined using non-linear acoustic scattering from the microbubble.

1                   24.    The method as claimed in claim 1, wherein the material  
2 includes a liquid or semi-liquid material, such as biological tissue.

1                   25.    An acoustic monitoring system in laser-induced optical  
2 breakdown (LIOB), the system comprising:  
3                   means for causing at least one acoustic wave associated with a  
4 microbubble to propagate in a volume of material;  
5                   an acoustic wave detector for detecting the at least one acoustic wave  
6 to obtain at least one signal; and

7 means for processing the at least one signal to obtain information  
8 which characterizes the material, the microbubble in the material or a  
9 microenvironment of the microbubble.

1 26. The system as claimed in claim 25, the information  
2 characterizes the mechanical microenvironment of the microbubble.

1 27. The system as claimed in claim 26, wherein the information  
2 characterizes the viscoelasticity of the microenvironment.

1 28. The system as claimed in claim 25, wherein the information  
2 characterizes microbubble size.

1 29. The system as claimed in claim 25, wherein the at least one  
2 acoustic wave includes at least one acoustic wave reflected from the microbubble  
3 and wherein the means for causing includes an acoustic source for directing acoustic  
4 energy to the material so that at least one acoustic wave propagates through the  
5 material to the microbubble to obtain the at least one reflected acoustic wave.

1 30. The system as claimed in claim 29, wherein the at least one  
2 reflected acoustic wave includes an ultrasound wave.

1 31. The system as claimed in claim 25, wherein the at least one  
2 acoustic wave includes an acoustic shock wave which propagates outwardly from  
3 an LIOB site and which defines an acoustic point source.

1 32. The system as claimed in claim 31, wherein the microbubble  
2 is LIOB-induced and wherein the acoustic shock wave defines position of the LIOB-  
3 induced microbubble which acts as an acoustic reflector.

1 33. The system as claimed in claim 31, wherein the point source  
2 is determined by location of an additive in the material and wherein the additive  
3 enhances an electric field in the vicinity of the additive.

1                   34.    The system as claimed in claim 33, wherein the information  
2 characterizes a photodisruption threshold of the material with the additive which is  
3 substantially lower than a photodisruption threshold of the material without the  
4 additive.

1                   35.    The system as claimed in claim 34, wherein the information  
2 quantifies concentration of the additive.

1                   36.    The system as claimed in claim 35, wherein a single molecule  
2 of the additive is detected.

1                   37.    The system as claimed in claim 33, wherein the material  
2 includes at least one nanodevice having the additive and a linked therapeutic agent  
3 and wherein at least one laser pulse causes the at least one nanodevice to release the  
4 linked therapeutic agent into the microenvironment.

1                   38.    The system as claimed in claim 37, wherein the information  
2 characterizes therapeutic efficacy of the therapeutic agent in the microenvironment.

1                   39.    The system as claimed in claim 31, wherein the material has  
2 an additive incorporated therein and wherein the point source is a desired point  
3 source substantially smaller than a point source defined by a microbubble created  
4 within the material without the additive.

1                   40.    The system as claimed in claim 39, wherein the additive  
2 includes metal nano particles or domains.

1                   41.    The system as claimed in claim 25, wherein the microbubble  
2 is produced by at least one laser pulse.

1                   42.    The system as claimed in claim 41, wherein the at least one  
2 laser pulse includes a focused laser pulse.

1                   43.     The system as claimed in claim 25, wherein the microbubble  
2     is produced by at least one ultrafast laser pulse.

1                   44.     The system as claimed in claim 43, wherein the information  
2     characterizes a photodisruption threshold of the material.

1                   45.     The system as claimed in claim 25, wherein the information  
2     characterizes location of the microbubble within the material.

1                   46.     The system as claimed in claim 25, wherein the information  
2     characterizes microbubble behavior in the material.

1                   47.     The system as claimed in claim 28, wherein the microbubble  
2     size is determined using non-linear scattering from the microbubble.

1                   48.     The system as claimed in claim 25, wherein the material  
2     includes a liquid or semi-liquid material, such as biological tissue.

1                   49.     The method as claimed in claim 1, wherein the information  
2     includes an acoustic image of the material.

1                   50.     The method as claimed in claim 7, further comprising time  
2     reversing the acoustic shock wave to form an acoustic image of the material.

1                   51.     The system as claimed in claim 25, wherein the information  
2     includes an acoustic image of the material.

1                   52.     The system as claimed in claim 31, further comprising means  
2     for time reversing the acoustic shock wave to form an acoustic image of the  
3     material.